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Acronyms, Abbreviations and Units

Acronyms and Abbreviations

BMP	Best Management Practice
Caltrans	California Department of Transportation
GSRD	Gross Solids Removal Device
LACWVCD	Los Angeles County West Vector Control District
LARWQCB	Los Angeles Regional Water Quality Control Board
ROW	Right-of-Way
RWQCB	Regional Water Quality Control Board
SWMP	Caltrans Statewide Storm Water Management Plan
TMDLs	Total Maximum Daily Loads
WLA	Waste Load Allocation
IS3 I-10	I-10 @ Halm: Inclined Screen – Configuration #3

Units

ac	Acre
ft	Feet
ft^3	Cubic feet
ft^3/ac	Cubic feet per acre
gpm	Gallons per minute
ha	Hectare
in	Inch
kg	Kilogram
kg/ha	Kilograms per hectare
KP	Kilometer Post
lb	Pounds
lb/ac	Pounds per acre
m	Meter
mm	Millimeter
m^3	Cubic meter
m^3/ha	Cubic meters per hectare
PM	Post Mile

Executive Summary

The objective of the Phase II Gross Solids Removal Devices (GSRDs) Pilot Study was to evaluate the performance of one non-proprietary device that can capture gross solids and that can be retrofitted into existing highway drainage systems. The term “gross solids” includes litter, vegetation, and other particles of relatively large size.

The design concept developed for this pilot study consists of an Inclined Screen device that utilizes a parabolic wedge-wire screen to screen out gross solids. The device was developed as a modification of the Inclined Screen – Configuration #1 GSRD tested in the Phase I GSRD Pilot Study. The Phase II GSRD uses a similar screen, but the device was designed so that it could be cleaned using front-end loader equipment. Installation cost for the pilot device, not including monitoring equipment, was $265,385 per hectare ($107,400 per acre).

Following a targeted storm event, the GSRD was visually inspected and assessed for screen clogging, proper drainage, and material accumulation. During each cleaning procedure, the weight and volume of gross solids removed from the device, bypass bag, and overflow basket were measured. The performance of the GSRD was assessed by evaluating how well it met the design objectives: the criteria set by the TMDL and criteria and goals set by Caltrans. The four criteria and two goals applied to the study are listed below.

TMDL Criteria	C1	Particle Capture	The device or system must capture all particles retained by a 5 mm (0.2 in nominal) mesh screen from all runoff generated from a one-year, one-hour storm (determined to be 0.6 in [15 mm] per hour for the Los Angeles River and Ballona Creek Watersheds).
	C2	Clogging	The device or system must be designed to prevent plugging or blockage of the screening module.
Caltrans Criteria	C3	Hydraulic Capacity	The device or system must pass the Caltrans design flow. In District 7, this design flow is the 25-year peak flow.
	C4	Drainage	The device or system must drain within 72 hours to avoid vector breeding.
Caltrans Goals	G1	Gross Solids Storage Capacity	The device or system will hold the estimated annual load of gross solids, so that it requires only one cleaning per year.
	G2	Maintenance Requirements	The device or system will not require any maintenance other than inspections throughout the storm season.

The Phase II GSRDs Pilot Study demonstrated proof of concept for the device tested. That is, a GSRD design that utilizes a front-end loader for cleaning is a feasible design. The parabolic wedge-wire screen utilized in the design can remove gross solids from storm water runoff. However, design modifications need to be incorporated, and a new pilot study conducted, before the device is recommended to the Los Angeles Regional Water Quality Control Board as a full capture treatment system. The design modifications would include: (1) a cover and (2) a re-design of the gross solids storage area. The purpose of the cover is to prevent the captured gross solids from escaping by wind. The purpose of the re-design is to prevent captured gross solids from being re-suspended and overflowing out of the device.

Section 1
Introduction and Study Design

1.1 OBJECTIVE

The Gross Solids Removal Devices (GSRDs) Pilot Program (Program) was initiated by the California Department of Transportation (Caltrans) to develop and evaluate the performance of non-proprietary devices that can capture gross solids and that can be constructed into existing highway drainage systems or implemented in future highway drainage systems. The term "gross solids" includes litter, vegetation, and other particles of relatively large size. The Caltrans *Guidance for Monitoring Storm Water Litter* (Caltrans, 2000) defines litter as "manufactured items made from paper, plastic, cardboard, glass, metal, etc. that can be retained by a 5 mm (0.2 in nominal) mesh screen."

1.2 BACKGROUND

Total Maximum Daily Loads (TMDLs) for trash in the Los Angeles River Watershed and the Ballona Creek Watershed have been adopted in Southern California. The requirements of these two TMDLs are discussed further in Sections 2 and 6. The non-proprietary devices developed and evaluated in the Program may be selected to meet the requirements of these two TMDLs. The Program consists of multiple phases with each phase representing one pilot study. A pilot study consists of one or more devices that have been developed from concept, have advanced through design and construction, and two years of pilot testing have been conducted for overall performance. Each pilot study consists of the following four general tasks:

- Task 1 - Concept Development
- Task 2 - Scoping, Preliminary Design, and Site Selection
- Task 3 - Final Design, Bidding, and Construction
- Task 4 - Monitoring and Performance Evaluation

The second pilot study in the Program is the Phase II GSRDs Pilot Study. Task 1 took place between November and December 2000. Task 2 took place between December 2000 and April 2001. Task 3 took place between June and August 2001. Task 4 took place between October 2001 and May 2003.

At the time this report was prepared, the Program included five pilot studies or phases. Figure 1-1 presents a timeline for monitoring of the five pilot studies. The Phase I GSRDs Pilot Study, consisting of eight devices, has completed monitoring and the final report has been published. The Phase III GSRDs Pilot Study, consisting of three devices, has completed the first year of monitoring with one more year remaining. The Phase IV GSRDs Pilot Study has finished design and is awaiting installation. The Phase V GSRDs Pilot Study is currently in design. Figures 1-2 and 1-3 present a summary of the devices in each phase of the study.

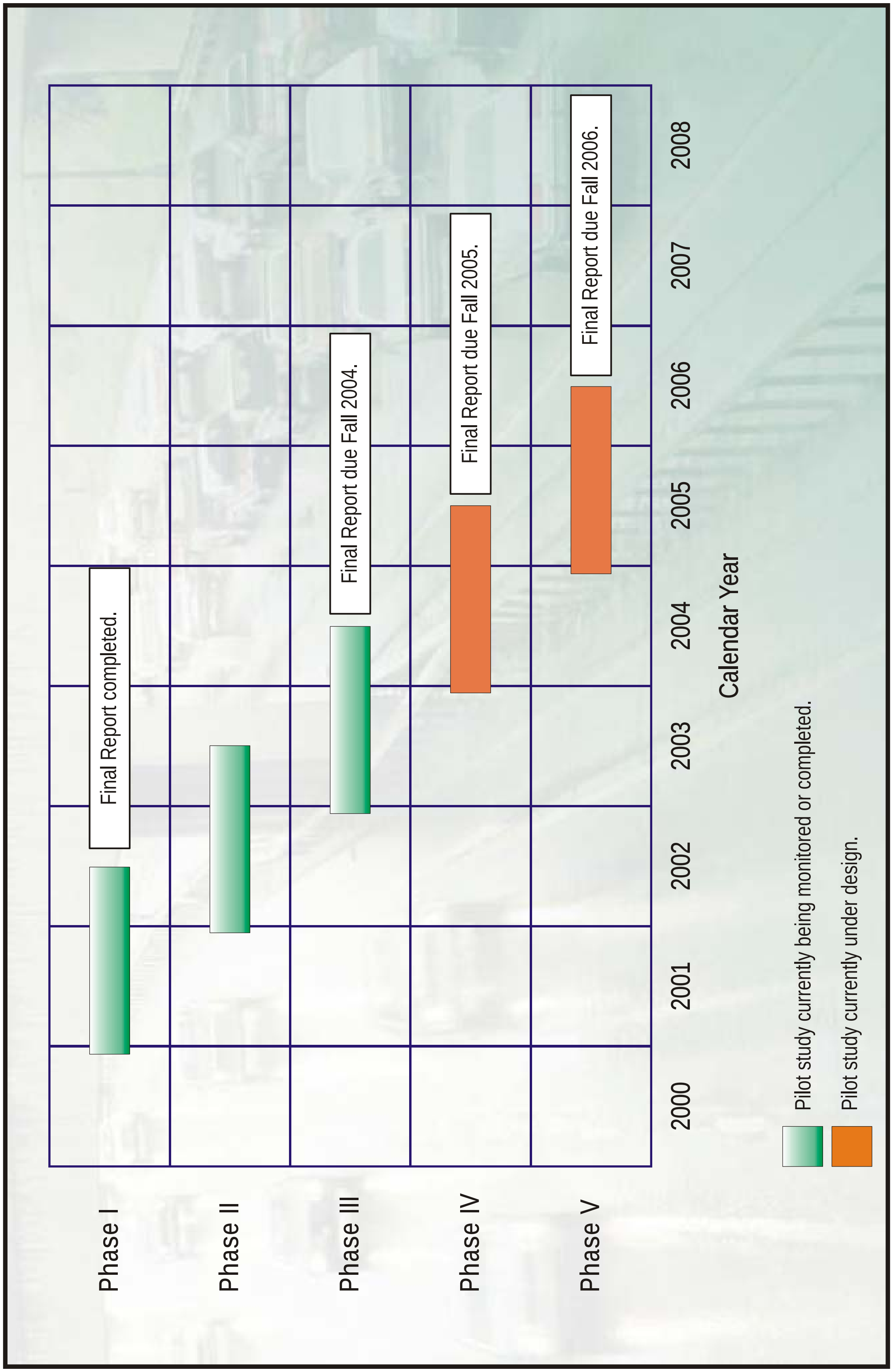

Figure 1-1
Monitoring Schedule for GSRD Pilot Studies

Phase I Devices

Linear Radial - Configuration #1

This GSRD utilizes a modular well-casing with 5 mm x 64 mm (0.2 in x 2.5 in nominal) louvers to screen out gross solids. The modular well-casing is placed on a 2 percent slope. Runoff flows into the device and exits radially through the louvers.

Linear Radial - Configuration #2

This GSRD utilizes a modular 5 mm x 5 mm (0.2 in x 0.2 in nominal) rigid mesh screen housing. Nylon mesh bags, 5 mm (0.2 in) openings, are placed inside the rigid mesh screen housing to capture gross solids. Runoff flows into the device and flows out of the nylon mesh bags.

Inclined Screen - Configuration #1

This GSRD utilizes a 3 mm (0.125 in nominal) spaced parabolic wedge-wire screen. Runoff enters the device and flows into a trough where larger gross solids settle out and the runoff is distributed. The distributed runoff flows over weirs and falls onto and through the screen. The gross solids are captured on the screen and moved by gravity to the storage area.

Inclined Screen - Configuration #2

This GSRD utilizes 5 mm (0.2 in nominal) spaced parabolic bars. Runoff enters the device and flows into a trough where larger gross solids settle out and the runoff is distributed. The distributed runoff flows over a weir and falls onto and through the bars while the gross solids are captured on the bars and moved by gravity to the storage area.

Baffle Box

This GSRD utilizes a two-chamber concept: the first chamber utilizes an underflow weir to trap floatable gross solids, and the second chamber uses a bar rack to capture materials that get past the underflow weir.

Phase II Devices

Inclined Screen - Configuration #3

This GSRD utilizes the same screen from the Inclined Screen - Configuration #1, Phase I Devices. This Phase II device has been modified to be cleaned by a front-end loader. The Inclined Screen - Configuration #1 is design to be cleaned out by a Vactor Truck.

Figure 1-2
Summary of Phases I and II Devices

Phase III Devices

V-screen - Configuration #1

This GSRD utilizes a forward sloping V-shaped 5 mm (0.2 in nominal) wedge-wire screen to remove gross solids. The screen is sloped forward so that the top of the screen is downstream from the bottom of the screen. Runoff flows through the screen horizontally, instead of falling on the screen as with the Inclined Screen - Configuration #1. This device does not utilize a trough.

V-screen - Configuration #2

This GSRD utilizes a reverse sloping V-shaped 5 mm (0.2 in nominal) wedge-wire screen to remove gross solids. The screen is sloped backward so that the top of the screen is upstream from the bottom of the screen. Runoff flows through the screen horizontally, instead of falling on the screen as with the Inclined Screen - Configuration #1. This device does not utilize a trough.

Inclined Screen - Configuration #4

This GSRD utilizes a 5 mm (0.2 in nominal) wedge-wire screen to remove gross solids. Runoff falls onto and through the screen. The gross solids are captured on the screen and moved by gravity to the storage area. This device does not utilize a trough as with the Inclined Screen - Configuration #1.

Phase IV Devices

Linear Radial - Configuration #3

This GSRD is generally the same design as the Linear Radial - Configuration #1, Phase I Devices. However, for this pilot study, the device will be constructed on an approximately 40 percent slope.

Phase V Devices

Concepts for the Phase V pilot study are currently being developed.

Figure 1-3
Summary of Phases III, IV, and V Devices

1.3 TERMINOLOGY

The following terminology is used in this report and is defined as follows:

- Bypass Bag – Nylon mesh bag with 5 mm (0.2 in nominal) opening, connected to the end of the downstream pipe, which collects any gross solids that pass through the screen.

- Overflow Structure – The overflow structure consists of the overflow weir and overflow basket.

- Overflow Basket – Metal basket that captures any gross solids that overtop the overflow weir. Overflow baskets are not applicable to all GSRDs.

- Overflow Condition – Condition that occurs when the water level reaches beyond the maximum level in the device, and inflow overtops the device. Most gross solids are captured in the overflow basket, but some solids may escape the overflow basket and are left unaccounted for. Overflow conditions can occur when 1) inflow exceeds the capacity of the GSRD screen, or 2) the screen is blinded.

- Wet Weight – Weight of the gross solids in the field without additional drying in the laboratory (as-collected weight of gross solids). Prior to transferring the gross solids to plastic trash bags, the solids are gravity drained for at least two minutes or until they are substantially drained of free water (e.g., no drips for 5 to 10 seconds).

- Wet Volume – Volume of the gross solids in the field without drying in the laboratory (as-collected volume of gross solids). Prior to transferring the gross solids to plastic trash bags, the solids are gravity drained for at least two minutes or until they are substantially drained of free water (e.g., no drips for 5 to 10 seconds).

1.4 REPORT ORGANIZATION

This report is organized as follows:

- **Section 1** presents the study objectives and background.

- **Section 2** presents the concept development and design criteria.

- **Section 3** summarizes the site selection, design, construction details, and construction costs.

- **Section 4** summarizes the monitoring procedures. A discussion of operations including the event summaries and general GSRD performance during the 2001–02 and 2002-03 monitoring season is also presented.

- **Section 5** presents the gross solids data collected during the 2001–02 and 2002-03 monitoring seasons.

- **Section 6** presents a summary of the overall performance of the GSRD during the 2001-02 and 2002-03 monitoring seasons.

- **Section 7** presents references cited in this report.

1.5 S.I. AND U.S. CUSTOMARY UNITS

This report provides units in both Standard International (S.I.) units and U.S. Customary units. In general, measurements and calculations are performed in S.I. units and converted to U.S. Customary units for reporting. Additionally, nominal dimensions of pipe diameters are provided, consistent with International Standards Organization (ISO) usage. For example, a 24 in pipe is referred to as a 600 mm pipe.

Section 2
Concept Development

2.1 DESIGN OBJECTIVES

The Phase II GSRD Pilot Study was designed to meet the criteria set by the Trash TMDL for the Los Angeles River and Ballona Creek Watersheds, and the criteria and goals set by Caltrans. The six design objectives listed below represent criteria and goals applied to the GSRDs. For this pilot study, meeting criteria held a higher importance than meeting goals. The following two criteria were set by the TMDLs for an approved full capture treatment system:

- The device or system will capture all particles retained by a 5 mm (0.2 in nominal) mesh screen from all runoff generated from a one-year, one-hour storm (determined to be 0.6 inch [15 mm] per hour for the Los Angeles River and Ballona Creek Watersheds).

- The device or system is designed to prevent plugging or blockage of the screening module.

The following two criteria were set by Caltrans for a GSRD:

- The device or system will pass the design flow as specified in the Caltrans Highway Design Manual (Table 831.3). For this pilot study, the design flow is the 25-year peak flow.

- The device or system will drain within 72 hours to avoid vector breeding.

Additionally, the following two goals were set by Caltrans for a GSRD:

- The device or system will hold the estimated annual load of gross solids, resulting in one cleaning per year.

- The device or system will not require any maintenance other than inspections throughout the storm season.

The design objectives are discussed further in Section 6.

2.2 CONCEPTUAL DESIGN

The Phase II GSRDs Pilot Study was developed to test one non-proprietary device designed to remove gross solids from storm water runoff in highway facilities, both in new installation and in retrofit settings. The development of the conceptual design is discussed below.

The Phase II Pilot Study consists of one concept. This concept represents a variation from one of the GSRDs evaluated under the Phase I Pilot Study. The Phase I Pilot Study consisted of three concepts: the Linear Radial, the Inclined Screen, and the Baffle Box (Caltrans, 2003). The Linear Radial and the Inclined Screen design concepts consisted of two variations.

The Phase II concept was developed from the Phase I GSRD: SR-170 at KP 26.1: Inclined Screen – Configuration #1. This Phase I GSRD was intended to be cleaned by a Vactor Truck. The Phase II concept utilizes the same treatment principles as the Phase I GSRD; however, the

Phase II concept had been altered so that a front-end loader with an 8 ft wide bucket can clean the GSRD. Additionally, the Phase II concept eliminated the trough from the Phase I GSRD. The purpose of the trough was to distribute flows along the length of the screen and provide an area of reduced velocity where solids can settle. The trough contained weep holes to drain any standing water that accumulated in it. Storm water runoff that collected in the trough did not always drain within the 72-hour target time due to clogging of the weep holes, until the weep holes were modified.

The Phase II concept developed as a result of several meetings with Caltrans Maintenance staff following the construction of the Phase I GSRDs. As previously mentioned, most of the Phase I GSRDs were intended to be cleaned by a Vactor Truck. The remaining Phase I GSRDs utilized mesh bags that could be replaced with new bags while the used bags could be cleaned off-site. Caltrans Maintenance staff expressed concern about the dependence on a Vactor Truck and a desire to utilize equipment readily available at Caltrans maintenance yards to clean GSRDs. One piece of equipment that is readily available is a standard front-end loader. Front-end loaders come in a variety of sizes with buckets ranging from 4 ft to 8 ft. Caltrans Maintenance staff requested that the Phase II GSRD be wide enough to accommodate an 8 ft wide bucket. The width of the bucket became the controlling factor in the width of the trash storage area. A summary of the design components applied to the Phase II GSRD is presented in the next section.

2.2.1 Inclined Screen GSRD

As shown in Figure 2-1, this device uses a wedge-wire screen to remove gross solids. The GSRD is configured with an upstream shelf to slow down the flow and evenly distribute it over the length of the screen. The flow overtops a weir and falls through an inclined screen located after the upstream shelf. After passing through the screen, the flow exits the GSRD. Gross solids are retained in a confined storage area that can be accessed by maintenance equipment. The device typically requires at least 0.9 m (3 ft) of head across the screen making this GSRD applicable for areas located within fill sections of highways.

- An upstream shelf is used to distribute flows along the length of the screen. Energy dissipaters are provided in this area to reduce the velocity of the incoming flows.
- The material captured by the screen is pushed down to the gross solids storage area by the storm water runoff, especially during large storm events.

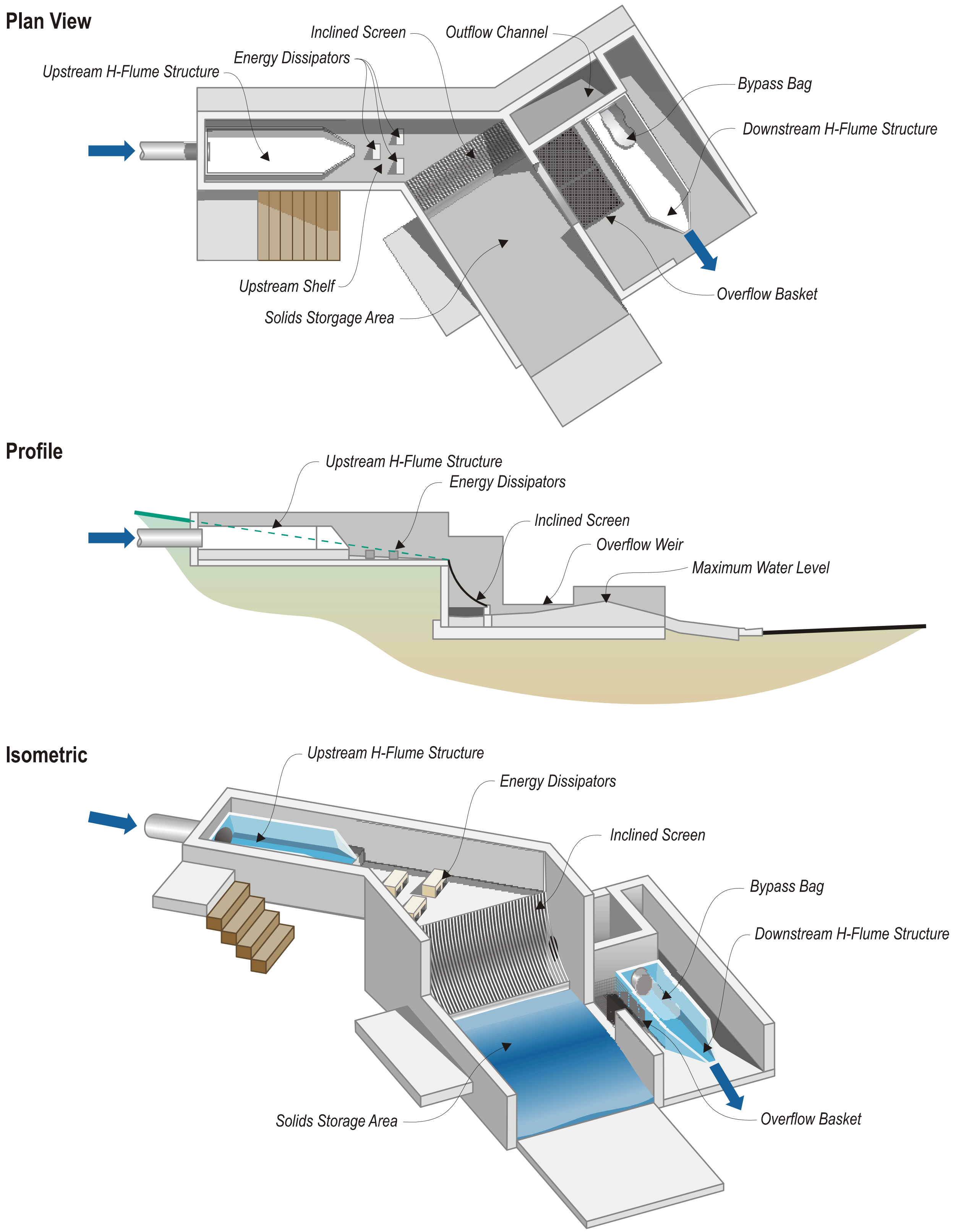

Figure 2-1
Inclined Screen – Configuration #3

2.3 DESIGN CRITERIA, PRELIMINARY DESIGN AND FINAL DESIGN

The design criteria applied for the Phase II Pilot Study included: primary design goals, hydrology, hydraulics, vector control, operation and maintenance objectives, and an estimated annual gross solids loading rate. The estimated annual gross solids loading rate used for this study is 0.7 m^3/ha (10 ft^3/yr). The gross solids loading rate and the other design elements applied to the Phase II GSRD are discussed in the *Basis of Design Report* (Caltrans, 2001b).

2.3.1 Design for Water Quality Monitoring

The design of the Phase II GSRD included H-flumes to rate the flows at the influent and effluent points. The H-flumes were intended to be used in conjunction with water quality monitoring equipment. At the completion of construction, the water quality monitoring component of the Phase II GSRD Pilot Study was removed. As a result, no water quality monitoring was conducted during the Phase II GSRDs Pilot Study. However, the H-flumes were left in place. The H-flumes would not be part of a standard design if the device were deployed to comply with the TMDL.

Section 3
Site Selection and GSRD Installation

3.1 SITE SELECTION

The site selection process for the Phase II Pilot Study, including the siting criteria, is discussed in the Basis of Design Report (Caltrans, 2001b). For the Phase I Pilot Study, the site selection process identified and ranked over 70 candidate sites. From these candidate sites, eight sites were selected for installation of pilot Phase I GSRDs. The candidate sites not selected for installation of the Phase I GSRDs were evaluated for the Phase II Pilot Study.

3.2 SITE DESCRIPTION

The site selected for the construction of the Phase II GSRD is located within District 7 and within the Ballona Creek Watershed. A site description is provided in Table 3-1. Figure 3-1 shows the approximate site location. Table 3-2 provides the naming convention that will be used throughout the rest of the report along with the drainage area characteristics. Descriptions and photos of the site are presented in the following subsections.

Table 3-1
Phase II GSRD Site Location Summary

Site ID	Site Name	GSRD Type & Configuration	City	Route	Direction	Kilometer Post KP (PM)
1	I-10 at Halm	Inclined Screen - 3	Los Angeles	10	Eastbound	13.6 (8.45)

Table 3-2
Phase II GSRD Site Characteristics Summary

Site ID	Site Name	GSRD Type & Configuration	Site Name Used in this Report	Watershed	Drainage Area ha (ac)	% Roadway Runoff	Roadway Inlets
1	I-10 at Halm	Inclined Screen - 3	IS3 I-10	Ballona Creek	1.3 (3.3)*	100%	5*

* Based on available record drawings (“As-Builts”). Detailed site surveys were not performed.

Figure 3-1
Phase II GSRD Location Map

3.2.1 Inclined Screen Device

The inclined screen device used a 5 mm (0.2 in nominal) spaced parabolic wedge wire screen, shown in Figure 3-2 below, with the slotting perpendicular (horizontal orientation) to the direction of flow. The screen used in this device was set at a steep, near vertical incline.

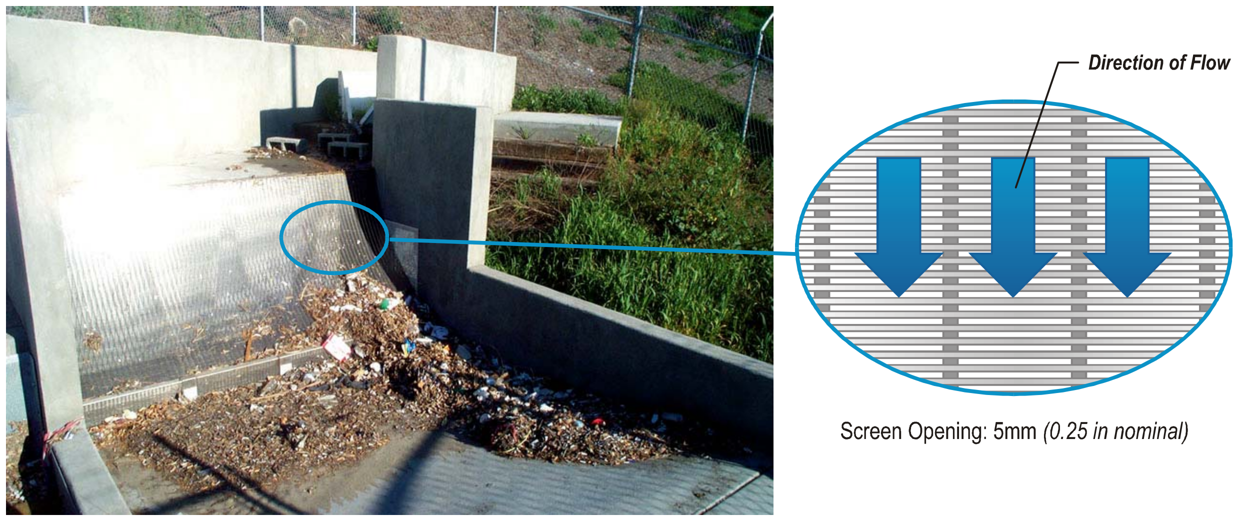

Figure 3-2
Configuration of Inclined Screen

3.2.1.1 I-10 at Halm: Inclined Screen – Configuration #3

This site is located in the City of Los Angeles on the eastbound side of I-10 at Halm Avenue, east of Robertson Boulevard and west of La Cienega Avenue. Access to the site for construction, maintenance, and monitoring purposes is from Halm Avenue. This site is characterized by:

- 5 inlets along the freeway shoulder
- 1 outlet, 450 mm (18 in) in diameter
- Drainage area of approximately 1.3 ha (3.3 ac)

This site is adjacent to the I-10 freeway in a fill section and within the Caltrans right-of-way (ROW). The site was selected due to adequate space available within the ROW, adequate hydraulic head, and convenient access from secondary streets.

Figure 3-3
IS3 I-10 After Installation

3.3 GSRD INSTALLATION SUMMARY

3.3.1 Installation Schedule

Installation of the IS3 I-10 site was performed from June 4, 2001 through August 23, 2001. The installation lasted 56 working days.

3.3.2 Installation Costs

Installation cost for the Phase II GSRD device is presented in Table 3.3. It is important to note that the installation of the device was done as a retrofit to the existing drainage system. Installation costs for similar devices at other locations may vary depending on specific site conditions.

Table 3-3
GSRD Installation Costs

No.	GSRD	Site	Drainage Area ha (ac)	Total Cost	Without Monitoring Equipment	
					Cost	Cost per hectare (acre)
1	Inclined Screen	IS3 I-10	1.3 (3.3)	$370,059	$345,000	$265,385 $107,400

[1]Total cost includes the cost of monitoring equipment. ENR Construction Cost Index =6233 (Aug. 2000)

3.3.3 Installation Issues

The installation of the Phase II GSRD proceeded as planned, with few unforeseen issues arising. Circumstances affecting the installation effort are described below, grouped by common issues.

3.3.3.1 Material Availability

There are lengthy shop drawings and manufacturing lead times associated with the wedge wire inclined screen. Manufacturers typically don't produce inclined screen with openings as large as 5 mm (0.2 in). Inclined screens are commonly used in the food processing industry, which requires smaller openings. For this project, the screens were ordered well in advance of the time frame in which they were needed, so there were no construction delays.

Upon receipt of the screens, it was determined that the screens did not fit properly due to quality control problems at the manufacturing plant. As a result, the screens had to be altered to the correct size and shape. Due to the responsiveness and quick turnaround of a metal working shop, the alterations did not delay or impact the construction work. The only impact was on the project cost.

3.3.3.2 Field Conditions

A large tree at the site was located just adjacent to the proposed location of the GSRD. Initially, it was thought that the tree would not have to be removed. Unfortunately, construction could not proceed in an efficient manner with the tree in place, so it was removed. Removal of the tree had the additional benefit of avoiding the problem of leaves dropping into the GSRD in the winter.

Relatively deep excavation in the upper slope of the roadway fill was required to tie into the outlet pipe. There was concern that the excavation might destabilize the roadway in that area. A geotechnical engineer was consulted, and his recommendations were adopted for the construction process. The geotechnical engineer was on site during the excavation at the top of the slope to ensure that the I-10 freeway remained stable.

3.3.3.3 Public Impact

The Phase II GSRD caused minimal impact to the Halm Avenue neighborhood during and after construction. The area of Halm Avenue where the GSRD is located is a cul-de-sac. Construction vehicles parked in the cul-de-sac, which caused minimal impact to neighborhood street parking. This impact was transitory in nature, and the construction crews always minimized the number of vehicles parked during the day. Additionally, the construction crew minimized the amount of construction equipment left at the site overnight.

Section 4
Monitoring and Operational Observations

4.1 OVERVIEW

This section summarizes the monitoring procedures for the Phase II Pilot Study and the operational observations for the device during the first storm season.

4.2 GROSS SOLIDS MONITORING

Detailed monitoring procedures for the 2001–02 and 2002-03 storm seasons are presented in the *Sampling and Analysis Plan* (Caltrans, 2001a). In summary, the following tasks were conducted following a targeted storm event:

- Took digital photos of the device
- Assessed device for clogging
- Estimated the amount of gross solids accumulation within the device to assess if an interim cleaning would be required
- Checked the bypass bag and overflow basket for material accumulation
- Verified that the device was draining properly

Data on accumulated gross solids was obtained whenever the device was cleaned and gross solids were removed from the device for measurements and ultimate disposal off the highway ROW. The device was designed to be cleaned only once per storm season. However, if the device reached approximately 85 percent of capacity by visual observation, or if extensive clogging or overflow was observed at the device, an additional cleaning was performed during the season. As a result, the device may have had more than one cleaning. During each cleaning procedure, up to four measurements were taken:

- Wet weight of the gross solids removed from the device
- Wet volume of the gross solids removed from the device
- Wet weight of the gross solids removed from the bypass bag and overflow basket
- Wet volume of the gross solids removed from the bypass bag and overflow basket

As mentioned above, weight and volume measurements were taken only during a cleaning procedure. If multiple cleanings were required at the site, the data from each interim cleaning and the end-of-season cleaning were added together for an annual gross solids loading for the site. Measurements were not taken on a per storm event basis. Section 5 summarizes the data wet weight and wet volume measurements.

4.2.1 Field Measurements

The volume of gross solids was estimated by placing the bags of gross solids (one at a time) into a container of known volume. The bag was made as level as possible across the entire surface area of the container. The amount of freeboard was then measured and multiplied by the surface area of the container to obtain the remaining volume. This quantity was then subtracted from the total known volume of the container to yield the estimated volume of gross solids. Field volume measurements from all bags for a single GSRD device were added together and the total volume calculated for that device.

The weight of gross solids was estimated by first placing the empty container on an electronic scale and taking the tare weight of the scale. The bags of gross solids (one at a time) were placed in the container, and weighed on the scale. Field weight measurements from all bags for a single GSRD device were added together and the total weight calculated for that device.

4.2.2 Mobilization Criteria

The field inspections during the storm season consisted of both post-storm inspections and during-storm inspections. Post-storm field inspections were conducted after a rain event that produced at least 13 mm (0.5 in) of rain. The threshold for mobilization for during-storm event inspections was set at 13 mm (0.5 in) minimum of forecasted rain. Field crews did not mobilize unless at least 13 mm (0.5 in) of rain was forecast with a minimum of 50 percent probability, and it had started raining. A National Weather Service (NWS) rain gage at the Santa Monica Airport, located about 8.8 kilometers (5.5 miles) from the site, was utilized for mobilization decisions.

4.3 GSRD OPERATION AND CLEANINGS

A summary of the operation and cleaning of the GSRD during the 2001–02 and 2002-03 storm seasons is presented in the following section. The average time and equipment required for the interim and post-season cleanings is presented in Table 4-1. This data represents the effort needed to clean the GSRD, collect the captured and bypassed gross solids, take field measurements of the weight and volume of gross solids, and dispose of the gross solids outside the Caltrans right-of-way.

For pilot project operations, gross solids are shoveled into bags for field measurements. Many times during cleaning, the gross solids are still partially wet, therefore taking longer to shovel and move the heavier material. The IS3 I-10 accumulates gross solids at various locations including the upstream shelf, solids storage area, overflow basket, outflow channel, and downstream flume. The areas are swept clean to account for all of the gross solids, and the screens are cleaned with a wire brush to remove and collect any accumulated material on the screens. Gross solids are also scraped and collected from the bypass bag and overflow basket. The bypass bag is checked for visible signs of any holes or rips.

Table 4-1
Phase II GSRDs Pilot Study Cleaning Requirements

Site	Average Man-hours per Storm Season	Equipment
IS3 I-10	24	Shovels, Rakes, Wheelbarrows, Pick-Up Truck

The cleaning efforts required for the pilot project are much greater than the level of effort expected for normal cleaning of the device due to the monitoring aspect of the pilot study. In the event that the device is approved by Caltrans for permanent use, and transferred to the District for operations and maintenance, the expected cleaning method for the GSRD will be with a front-end loader. The expected cleaning for the IS3 configuration requires shoveling of gross solids collected in the solids. The overflow basket will not be part of a standard design for the IS3.

4.3.1 I-10 at Halm: Inclined Screen – Configuration #3

The IS3 I-10 GSRD was monitored during the 2001–02 storm season. The device was inspected eight times and cleaned once at the end of the season. No interim cleanings were required for this site. However, maintenance was performed on February 13, 2002 to move solids from the overflow basket to the solids storage area. Operational issues observed include: (1) minor blinding of the screens, (2) overflowing, (3) sediment accumulation, and (4) growth of vegetation within the device. On December 14, 2002, an inspection was performed during a rain event with an observed flow between 2 to 6 gpm. No operational or performance issues were reported from this inspection.

During the 2002-03 storm season, the IS3 I-10 GSRD was inspected six times and cleaned out once at the end of the season. Inspection reports indicated that the device experienced the same operational issues as during the first season. The IS3 I-10 site regularly experienced water flow into the overflow basket, as well as flow beyond the high point of the solids storage area. No interim cleaning was required for the site. However, there was vegetation growth observed in the upstream flume, which had to be removed.

The overflows observed during both storm seasons were caused by the clogging of the bypass bag. Observations noted that the bypass bag clogged due to fine organic material, smaller than the openings of the parabolic wedge-wire screen, which was trapped in the bypass bag. The clogged bypass bag caused a backwater effect in the device. The backwater effect caused the level of water in the gross solids storage to rise until the level of water reached the overflow weir. As a result, captured gross solids from previous storm events were re-suspended and transported into the overflow basket.

Vegetation growth occurred in the influent section of the device that contains the influent H-flume and energy dissipaters. The vegetation growth resulted from the flat slopes of the H-flume. These flat slopes allowed approximately 4 in to 6 in of sediment to settle out of the storm water influent. Vegetation grew as the storm season progressed.

Figure 4-1
IS3 I-10 During Monitoring

4.3.2 Gross Solids Disposal

Gross solids were not tested before disposal, since most of the collected material consisted of vegetation, sediment and litter such as cardboard and plastic. The gross solids were disposed of at dumpsters located at the yards of the contractors performing the cleaning and monitoring. No special handling techniques, e.g., hazardous suits or breathing apparatuses, were required during the cleaning operations.

4.4 VECTOR MONITORING

For the Phase II GSRDs Pilot Study, the Los Angeles County West Vector Control District (LACWVCD) was contracted to provide vector surveillance and control services at each GSRD from October 2001 through July 2002. The site was monitored on a weekly basis. The numbers of potential and actual mosquito sources as well as the number of dips taken at each individual source were recorded. Larval samples were identified to species. The size of the areas treated and amounts of control agents applied were also recorded.

During the vector-monitoring period, no breeding activity was detected. As a result, no abatement was required. However, while breeding activity was not detected, a number of potential sources for breeding were identified by LACWVCD during field inspections. Potential sources for breeding activity included litter, such as cups, that could retain storm water after the device has drained and the accumulation of sedimentation in the influent approach section, where the H-flume is located, which could allow storm water to pond.

Section 5
Annual Gross Solids Loading and Capture Efficiency

5.1 GROSS SOLIDS DATA

The Phase II Pilot Study monitored one device over the 2001-02 and 2002–03 storm seasons. The gross solids data collected at this device for the two storm seasons is presented in Table 5-1. The data consisted of measuring the wet weight and wet volume of the captured gross solids during interim and post season cleanings. The captured gross solids included the gross solids contained within the device, within the bypass bag, and within the overflow basket (if applicable). Table 5-1 also presents the number of cleanings required at the device. Table 5-2 summarizes the annual gross solids loading, normalized by area, by wet weight and wet volume.

From Table 5-1, the total gross solids weight and volume measured at the site changed from the 2001-02 season to the 2002-03 season. This pilot study did not investigate the seasonal variability of gross solids deposition. Some possible reasons for the seasonal variation are annual amount of rainfall, intensity and duration of storm events, and amount of wind blown material deposited.

As a result of the change in the total gross solids weight and volume at the site, the annual gross solids loading rate calculated at the site, presented in Table 5-2, also changed from the 2001-02 season to the 2002-03 season. The variability of the gross solids loading rate is discussed further in Section 6.7.2.

Table 5-1
Annual Wet Weight and Wet Volumes of Gross Solids and Cleaning Performance

Site	2001-02			2002-03		
	Number of Cleanings	Total Wet Weight[1] kg (lbs)	Total Wet Volume[2] m^3 (ft^3)	Number of Cleanings	Total Wet Weight[1] kg (lbs)	Total Wet Volume[2] m^3 (ft^3)
IS3 I-10	1	186.5 (411.2)	0.75 (26.4)	1	1,411.8 (3,112.4)	1.97 (69.4)

[1] Total wet weight includes the weight of gross solids captured within the device, within the bypass bag, and within the overflow basket (if applicable). As previously discussed in Section 4, the weight of gross solids was measured by placing each bag of collected gross solids on an electronic scale.

[2] Total wet volume includes the volume of gross solids captured within the device, within the bypass bag, and within the overflow basket (if applicable). As previously discussed in Section 4, the volume of gross solids was estimated by placing each bag of collected gross solids into a container of know volume. The gross solids were hand-leveled. The amount of freeboard was then measured and multiplied by the surface area of the container. This quantity was subtracted from the known volume to yield the estimated volume of gross solids.

Note: For reporting purposes, total wet weight for both S.I. units and U.S. Customary have been reported to the nearest tenth. Total wet volume in S.I. units has been reported to the nearest hundredth and to the nearest tenth in U.S. Customary units.

Table 5-2
Area-Normalized Annual Gross Solids Loading by Wet Weight and Wet Volume

Site	Total Area ha (ac)	2001-02		2002-03	
		Weight per Unit Area kg/ha (lbs/ac)	Volume per Area m^3/ha (ft^3/ac)	Weight per Unit Area kg/ha (lbs/ac)	Volume per Area m^3/ha (ft^3/ac)
IS3 I-10	1.3 (3.3)	143.5 (124.6)	0.58 (8.0)	1,086.0 (943.2)	1.52 [1] (21.0) [1]

[1] Approaches or exceeds the design value of 0.7 m^3/ha/yr (10 ft^3/ac/yr), presented in Section 2.3.

Note: For reporting purposes, total drainage area for both S.I. units and U.S. Customary has been reported to the nearest tenth. The weight per unit area for both S.I. units and U.S. Customary has been reported to the nearest tenth. The volume per unit area in S.I. units has been reported to the nearest hundredth and to the nearest tenth in U.S. Customary units.

5.2 CAPTURE EFFICIENCY

The gross solids capture efficiency was calculated by comparing the weight or volume of gross solids captured in the downstream bypass bag and overflow basket with the gross solids captured in the device:

$$Capture\ Efficiency = \frac{\left(\begin{array}{c}Solids\ Caught\\ in\ GSRD\end{array}\right)}{\left(\begin{array}{c}Solids\ Caught\\ in\ GSRD\end{array}\right)+\left(\begin{array}{c}Solids\ Caught\\ in\ Bypass\ Bag\end{array}\right)+\left(\begin{array}{c}Solids\ Caught\\ in\ Overflow\ Basket\end{array}\right)}\times 100\%$$

Capture efficiencies by volume for the device over the two storm seasons is presented in Table 5-3. Additionally, capture efficiencies by weight for the device over the two storm seasons are presented in Table 5-4. The volumes and weights presented in these tables and figures are the annual sum of the volumes and weights of gross solids captured within the device, within the bypass bag, and within the overflow basket, during an entire storm season. The capture efficiency by volume and weight changed at the site from the 2001-02 season to the 2002-03 season. The change in capture efficiency at the site occurred without a change in operation of the GSRD. It is not known why the capture efficiency changed.

The GSRD was designed to meet the requirements of a full capture treatment system defined by the Los Angeles River and Ballona Creek Total Maximum Daily Load (TMDL) for trash. These TMDLs define a "full capture treatment system" as "…any device or system that traps all particles retained by a 5 mm mesh screen and has a design treatment capacity of not less than the peak flow resulting from a one-year, one-hour storm (determined to be 0.6 inch per hour for the Los Angeles River watershed)" (LARWQCB, 2001a). The monitoring strategy employed for this study specified measuring the gross solids at the time cleanings were performed at each device, but not after every storm event.

The pilot project study was not designed to determine the amount of gross solids that were bypassed on a per-storm event basis. Consequently, it is not possible to determine if the bypasses occurred during storm events greater than the design storm that would be allowed under the TMDL or less than the design storm which would violate the TMDL. Furthermore, it is not possible to tell whether the gross solids captured in the bypass bag and overflow basket escaped the GSRD during bypass events or normal operations. The presumption is that these gross solids escaped only during high flows.

Table 5-3
Gross Solids Removal Efficiency by Wet Volume

Site	2001-02				2002-03			
	Captured Gross Solids m^3 (ft^3)	Bypass Gross Solids [1, 2] m^3 (ft^3)	Total Gross Solids m^3 (ft^3)	Removal Efficiency (%)	Captured Gross Solids m^3 (ft^3)	Bypass Gross Solids[1, 2] m^3 (ft^3)	Total Gross Solids m^3 (ft^3)	Removal Efficiency (%)
IS3 I-10	0.71 (25.1)	0.04 (1.31)	0.75 (26.4)	95	1.76 (62.2)	0.20 (7.2)	1.97 (69.4)	90

[1] Site experienced overflows at the GSRD and at the bypass basket or bag. Therefore, a limited amount of gross solids left the system unaccounted for. As a result, the calculated removal efficiency may be overstated.

[2] "Bypassed gross solids" is the amount of gross solids that was captured in the bypass structure or bag at each GSRD.

Note: For reporting purposes, total wet volume in S.I. units has been reported to the nearest hundredth and to the nearest tenth in U.S. Customary units.

Table 5-4
Gross Solids Removal Efficiency by Wet Weight

Site	2001-02				2002-03			
	Captured Gross Solids kg (lb)	Bypass Gross Solids** kg (lb)	Total Gross Solids kg (lb)	Removal Efficiency (%)	Captured Gross Solids kg (lb)	Bypass Gross Solids** kg (lb)	Total Gross Solids kg (lb)	Removal Efficiency (%)
IS3 I-10	177.8 (392.0)	8.7 (19.2)	186.5 (411.2)	96	1,266.8 (2,792.8)	145.0 (319.7)	1,411.8 (3,112.5)	90

[1] Site experienced overflows at the GSRD and at the bypass basket or bag. Therefore, a limited amount of gross solids left the system unaccounted for. As a result, the calculated removal efficiency may be overstated.

[2] "Bypassed gross solids" is the amount of gross solids that was captured in the bypass structure or bag at each GSRD.

Note: For reporting purposes, total wet weight in S.I. and in U.S. Customary units has been reported to the nearest tenth.

Section 6
Discussion and Summary

6.1 COMPLIANCE WITH THE TMDL

The California Regional Water Quality Control Board, Los Angeles Region (LA RWQCB) has developed total maximum daily loads (TMDLs) that are designed to attain the water quality standards for trash in the Los Angeles River (LA RWQCB, 2001a) and Ballona Creek (LA RWQCB, 2001b). A TMDL represents the total amount of a given pollutant that can be released into a water body consistent with the goal of restoring and ultimately maintaining beneficial uses designated for the water body. A waste load allocation (WLA) allocates this total maximum daily load among all dischargers of that pollutant to a particular waterway. The final WLA for the Trash TMDLs for the Los Angeles River and Ballona Creek Watersheds is set at zero and will be met over a period of 12 years through a phased reduction. This phased reduction means that Caltrans will retrofit a percentage of its outfalls that drain into the Los Angeles River and Ballona Creek Watersheds each year until all the outfalls have been retrofitted within the time frame.

The TMDL regulations state that areas served by a full capture treatment system will be considered in compliance with the final WLA, provided that the full capture treatment system is adequately sized and maintained, and maintenance records are available for inspections by the LA RWQCB (LA RWQCB, 2001a). The TMDLs identify the vortex separation system as an approved full capture treatment system. Other devices or systems, such as the GSRD tested in this study, may be employed, but must be approved by the Executive Officer of the LA RWQCB before removal credit is granted. The criteria for a full capture treatment system are provided in Section 2.1 and in the next section.

6.2 OVERALL GSRD PERFORMANCE

The overall performance of each GSRD was assessed by evaluating how well the GSRD met the different design objectives listed in Section 2.1 and repeated below. The design objectives include four performance criteria established by the TMDL and Caltrans, and two additional performance goals set by Caltrans. A GSRD cannot be considered a success unless it meets all four performance criteria. Beyond this consideration, the extent to which a GSRD meets the two performance goals assesses its desirability as compared with another GSRD.

The following two performance criteria were set by the TMDL for an approved full capture treatment system:

C1	Particle Capture	The device or system must capture all particles retained by a 5 mm (0.25 in nominal) mesh screen from all runoff generated from a one-year, one-hour storm (determined to be 15 mm [0.6 inch] per hour for the Los Angeles River Watershed).
C2	Clogging	The device or system must be designed to prevent plugging or blockage of the screening module.

The following two performance criteria were set by Caltrans:

C3	Hydraulic Capacity	The device or system must pass the Caltrans design flow. In District 7, this design flow is the 25-year peak flow.
C4	Drainage	The device or system must drain within 72 hours to avoid vector breeding.

Additionally, the following two performance goals were set by Caltrans:

G1	Gross Solids Storage Capacity	The device or system will hold the estimated annual load of gross solids, so that it requires only one cleaning per year.
G2	Maintenance Requirements	The device or system will not require any maintenance other than inspections throughout the storm season.

6.3 GSRD PERFORMANCE CRITERIA

The TMDL and Caltrans criteria represent design objectives for the pilot study that must be met by the GSRD for consideration for future deployment.

6.3.1 Criterion C1 - Particle Capture

For this pilot study, the word "all" stated in the first TMDL criterion is interpreted to mean 100 percent of the particles at or greater than the targeted size. Furthermore, it is assumed that particles captured during one storm event are not allowed to be re-suspended and released back into the storm drain system by subsequent storms. In this pilot study, particles retained by a 5 mm (0.2 in nominal) mesh screen are assumed to be the same as particles retained by a 3 mm (0.125 in nominal) spaced parabolic wedge-wire screen. This assumption was verified through observations, as discussed in Section 4.3.1.

The measured capture efficiency of the IS3-I-10 was less than 100 percent for each storm season. During each storm season, it is presumed that the GSRD bypassed gross solids or overflowed only in storms greater than the TMDL design storm, as discussed in Section 5.2. From operational observations during storm events through both storm seasons, gross solids overflowed from the gross solids storage area into the overflow basket. The gross solids in the overflow basket included both gross solids that had been transported during the monitored storm event and gross solids that had been captured in previous storm events, re-suspended, and transported into the overflow basket by the monitored storm event. Due to the re-suspension of the captured gross solids, the device does not meet the Particle Capture Criterion. The re-suspension of the captured gross solids for the both storm seasons is believed to be caused by the clogging of the bypass bag, as discussed in Section 4.3.1.

One additional note, as seen in Table 5-2, the gross solids loading rate for the 2001-02 storm season was twice the design value. As a result, it was expected that the device would bypass more gross solids in the second storm season than in the first. This expectation was verified in Tables 5-3 and 5-4.

6.3.2 Criterion C2 - Clogging

As discussed in Section 4.3.1, the GSRD did not experience any clogging of the parabolic wedge-wire screen. Minor blinding of the screen was noted, but this blinding did not require any corrective action. Clogging was noted for the bypass bag and overflow basket. Both the bypass bag and overflow basket were utilized for monitoring purposes only and would not be included in the design if the device is approved for deployment. Therefore, since the parabolic wedge-wire screen did not clog and the bypass bag and overflow basket are only included for monitoring purposes during the pilot study, the device is considered to have met the clogging criterion.

6.3.3 Criterion C3 - Hydraulic Capacity

In general, the GSRD was designed to capture the estimated annual amount of gross solids and convey the Caltrans design flow. For this pilot study, the Caltrans Highway Design Manual and local criteria from District 7 required the GSRD to convey the 25-year peak flow. The purpose of this requirement is to prevent storm water from backing up onto the freeway. Because the GSRD was designed to safely bypass flows in excess of the 25-year peak flow, the GSRD is presumed to meet this criterion. The 25-year storm event or greater was not observed during the pilot study.

6.3.4 Criterion C4 - Drainage

The GSRD was designed to drain within 72 hours to prevent vector breeding. The maintenance inspections and the vector inspections did not identify any issues with the drainage of the device. However, maintenance was required to clean the bypass bag and overflow basket to improve the flow of storm water through the device. Since the bypass bag and overflow basket are only included for monitoring purposes during the pilot study and would not be included in a standard design, the device was considered to have met the 72-hour drain time.

6.4 GSRD PERFORMANCE GOALS

The purpose of the two Caltrans goals was to reduce the maintenance effort, time, and equipment needed for each GSRD. The goals represent desirable features to maintain and operate the approximately 2,600 outfalls that will need to be retrofitted for compliance with the Los Angeles River Watershed and Ballona Creek Watershed TMDLs for trash. As a result, GSRDs that do not meet the goals may not necessarily be disqualified, though they would not be preferred devices.

6.4.1 Goal G1 - Gross Solids Storage Capacity

As previously mentioned, each GSRD was designed to capture the estimated annual load of gross solids, which would result in one cleaning per year. As presented in Table 5-1, only one cleaning was required at the end of each storm season throughout the pilot study.

As discussed in Section 4.3.1, gross solids overflowed from the gross solids storage area into the overflow basket throughout both storm seasons because of the bypass bag clogging. Due to the amount of gross solids that overflowed, maintenance was required to clean the overflow basket and bypass bag. A portion of the annual amount of gross solids that would have been captured in the gross solids storage area was removed during the maintenance activities in the overflow basket. Because of the overflow of gross solids, it is uncertain if the device met the Caltrans goal for gross solids storage capacity. Additionally, the gross solids loading rate for the 2001-02 storm season was twice the design value. If the gross solids had not overflowed the device, it is expected that the device would have required more than one cleaning.

6.4.2 Goal G2 - Maintenance Requirements

During the two storm seasons, maintenance was required during both seasons for the overflow basket and the bypass bags to clear clogging. As mentioned in Section 6.3.2, the bypass bag and overflow basket were utilized for monitoring purposes only and would not be included in the standard design. As a result, it is uncertain whether the device met the maintenance requirements goal.

6.5 SUMMARY EVALUATION

Table 6-1 summarizes how well the GSRD met the performance criteria and goals discussed in Sections 6.3 and 6.4. Table 6-2 summarizes the strong points, weak points, and potential to correct deficiencies for the IS3 I-10.

The IS3 I-10 demonstrated proof of concept for the device tested. That is, a GSRD design that utilizes a front-end loader for cleaning is a feasible design. The parabolic wedge-wire screen utilized in the design can remove gross solids from storm water runoff. However, design modifications need to be incorporated, and a new pilot study conducted, before the device is recommended as a full capture treatment system. The design modifications would include: (1) a cover and (2) a re-design of the gross solids storage area. The purpose of the cover is to prevent the captured gross solids from escaping by wind. The purpose of the re-design is to prevent captured gross solids from being re-suspended and overflowing out of the device.

Table 6-1
GSRD Pilot Performance Summary in Relation to Design Criteria and Goals

Criteria (C) or Goal (G)	Performance
C1 Particle Capture	No. Annual capture efficiency >90% but solids re-suspended and overflowed into overflow basket.
C2 Clogging	Yes.
C3 Hydraulic Capacity	Presumably. Device designed to pass 25-yr storm but such an event was not observed during the study.
C4 Drainage	Yes.
G1 Solids Storage	Uncertain. The device was observed to have overflowed into the street.
G2 Maintenance Requirement	Uncertain. Maintenance required to unclog the overflow basket.

Table 6-2
Summary of Performance Characteristics for Phase II GSRD

Strong Points	Weak Points	Potential to Correct Deficiencies
▪ Parabolic wedge-wire screen worked well to screen out gross solids ▪ Met C2 (Clogging) if bypass bag was not considered ▪ Presumed to have met C3 (Hydraulic capacity) ▪ Met C4 (drainage) if bypass bag was not considered	▪ Clogging of the overflow basket and bypass bag observed. The screen did not clog ▪ Uncovered device allows wind-blown material into the device. The wind-blown material can enter the storm drain system following a storm event ▪ Overflow of gross solids into street only noticed when overflow basket and bypass bag plugged	▪ Bypass bag and overflow basket would not be considered as part of a standard design ▪ Provide cover for the device (i.e., grating) ▪ Add higher overflow weir at entrance of device to provide greater solids storage capacity

6.6 REGIONAL BOARD APPROVAL

As mentioned in Section 6.1, any full capture treatment system that is not a vortex separation system will need approval from the RWQCB's Executive Officer before removal credit will be granted. Coordination with the RWQCB will be required to start the process of getting any of the proposed GSRDs approved. At this time, the IS3 I-10 is not recommended for RWQCB approval.

6.7 ADDITIONAL PILOT STUDY OBSERVATIONS

As previously mentioned, the design criteria for IS3 I-10 is summarized in the *Preliminary Design Report* (Caltrans, 2001b) and the *Basis of Design Report* (Caltrans, 2001c). After monitoring the Phase II GSRD for two storm seasons, important observations were made which can be applied to future GSRD designs.

6.7.1 Bypass Bag

From visual observations, partial plugging of the bypass bag seemed to be the biggest factor in causing the device to overflow. During the storm-event inspection conducted on February 12, 2003, it was noted that the bypass bag at the outflow pipe was blinded by fine organic material, restricting the outflow and causing an artificial backwater in the device. The water then backed up through the inclined screen and into the solids storage area. This backwater caused the water level to rise in the solids storage area, and consequently flow into the overflow basket. There was also evidence during visual inspections that the water level regularly reached beyond the high point, discharging solids onto the street. If IS3 I-10 is to be transferred to District 7 for operation and maintenance, the bypass bag will be eliminated.

6.7.2 Overflow Structure

The overflow structure at the IS3 I-10 is adequately sized and performed as expected. However, in future designs a dedicated emergency overflow from the overflow structure should be provided. The overflow structure was utilized on several occasions during both storm seasons. The reason for this overflow is discussed in the section above.

6.7.3 Gross Solids Loading Rate

The estimated annual gross solids loading by volume for design was 0.7 m^3/ha (10 ft^3/ac). This design number was applied to the IS3 I-10 so that, on average, the GSRD would be cleaned only once per storm season. In general, when the estimated annual loading of gross solids is exceeded at a site, additional cleanings may be required. As discussed in Section 6.3.1, the gross solids loading rate for the 2001-02 storm season was more than twice the design value. However, only one cleaning was required during the storm season. Only one cleaning was required due to the amount of gross solids that overflowed into the overflow basket. The overflow basket was cleaned periodically.

Over the two storm seasons, the IS3 I-10 exhibited an annual gross solids loading rate less than the design value the first season and more than the design value the second season. Furthermore, the annual gross solids loading in the 2002-03 season was almost 3 times the 2001-02 annual gross solids loading. As shown in Table 5-2, the gross solids loadings by volume ranged from 0.58 m^3/ha (8.0 ft^3/ac) to 1.52 m^3/ha (21.0 ft^3/ac).

Due to these variations in the calculated annual gross solids loading rate for the GSRD, further investigation and refinement of the estimated annual gross solids loading for design may be warranted to meet the target of one cleaning per storm season. Additionally, designs that are easily expanded in the field should be investigated due to the variations in annual gross solids loading.

6.7.4 Gross Solids Storage

Another observation made through the pilot study is the need to provide for sufficient gross solids storage. The IS3 I-10 was designed to accommodate a front-end loader, which provided a fixed minimum width for the screen and solids storage area. However, the IS3 I-10 did not provide for sufficient depth, as a large amount of gross solids flowed to the overflow basket. As a result, the overflow basket became plugged, and water levels rose such that solids overflowed the high point of the device.

6.7.5 Proposed Design Modifications

As discussed in Section 6.5, design modifications need to be incorporated, and a new pilot study conducted, before the device is recommended as a full capture treatment system. The design modifications would include: (1) a cover and (2) a re-design of the gross solids storage area.

6.7.5.1 Cover

The purpose of the cover is to prevent the captured gross solids from escaping by wind. The cover must be easily removed and replaced since the gross solids storage area must be accessed by a front-end loader for cleaning and maintenance crews for inspections.

6.7.5.2 Re-design of Gross Solids Storage Area

The purpose of the re-design is to prevent captured gross solids from being re-suspended and overflowing out of the device. Two modifications should be considered in future designs of an IS3. These changes include reconfiguration of the access ramp. The ramp should be redesigned to be longer with a more gradual slope. This would make cleaning with a front-end loader easier. The second would be to create a curb that the bottom of the screen would rest on. This curb would give the front-end loader something more durable to press against when cleaning the device.

Section 7
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